Ozone loss and detailed investigations on the chemistry in the core of FrIAC's (Frozen In Anticyclones) events occurring in 2007 and 2011

Nathalie Huret, Rémi Thiéblemont, Fabrice Jégou, A. Søvde, Y. J. Orsolini, M.-A. Drouin

Ozone loss and detailed investigations on the chemistry in the core of FrIAC's (Frozen In Anticyclones) events occurring in 2007 and 2011 (#6091).

N. Huret [1], R. Thiéblemont [1], F. Jegou [1], A. Søvde [2], Y.J. Orsolini [3], and M.-A. Drouin [1]

[1] LPC2E/CNRS & Université d'Orléans, France, [2] Center for International Climate and Environmental Research – Oslo, Norway, [3] NILU, Norway

ABSTRACT :

During springtime, after the final stratospheric warming, the breakdown of the polar vortex occurs and the summer circulation starts to develop. Air mass intrusions from the tropics can be trapped into the polar latitudes in an anticyclone which can persist until August, advected by summer easterlies. These structures, named "Frozen In Anticyclones" (FrIACs), have already been observed in 2003, 2005 and 2007 by MIPAS-ENVISAT and MLS-AURA instruments [*Lahoz et al.*, 2007, *Manney et al.*, 2006, *Thiéblemont et al.*, 2011]. These FrIACs lead to an irreversible ozone loss in the tropics.

Here, we present a new case of FrIAC occurring in 2011. It is the major one in term of spatial extent since 1960 (see poster #6072). Using MIPAS, MLS tracer species and ozone measurements, we characterize in detail its duration and location in comparison with the previous FrIAC event in 2007. We compared simulations using several CTM models, and evaluated them against measurements. Then we examined the specific chemistry in the core of the FrIAC.

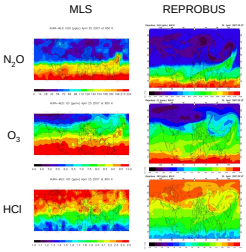
TOOLS :

The 2007 FrIAC event has been investigated using N_2O and O_3 measurements from Microwave Limb Sounder on Aura satellite platform whereas the 2011 FrIAC event has been investigated using a combination of MIPAS/ENVISAT and MLS/AURA satellite measurements, due to a lack of MLS data during the onset of the FrIAC. To characterize each event, we focus our study on the 850 K isentropic surface (i.e. ~10 hPa, ~30 km), where the FrIAC signal is the strongest [*Thiéblemont et al.*, 2011].

Measurements are compared with the results of two CTM models : REPROBUS [*Lefèvre et al.*, 1994] and the Oslo CTM [*Søvde et al.*, 2011], which have an horizontal resolution of 1°x1° and 2.7°x2.7°, respectively.

The 2007 FrIAC Event : Comparison MLS/REPROBUS

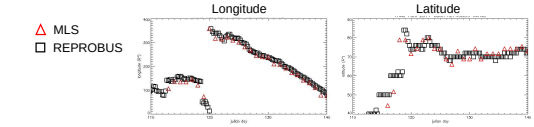
➢ On the 25 April 2007 : Intrusion



VMR (core FrIAC)	MLS	REPROBUS
N_2O ppbv	183-196	120-140
O_3 ppmv	9-9.5	8.4-8.7
HCl ppbv	1.6-1.7	1.8-2

During the first stage of the FrIAC (i.e. tropical intrusion), the REPROBUS model well represents the location of the tropical intrusion. However the maximum value of **N_2O inside the tongue is underestimated** due **to a smaller extent of the intertropical band simulated by the model**. O_3 and HCl appears consistent with the satellite data.

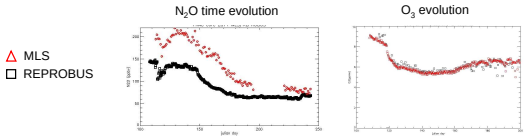
➢ Location of the core of the FrIAC : MLS/REPROBUS



The location of the core of the FrIAC, on the 850 K isentropic surface as a function of julian day, has been extracted from the MLS Data and the results of REPROBUS using the criteria of the maximum value of N_2O mixing ratio at 850 K.

The model **well represents** the evolution of the location (latitude and longitude) of the FrIAC core.

➢ N_2O and Ozone evolution in the core of the FrIAC :

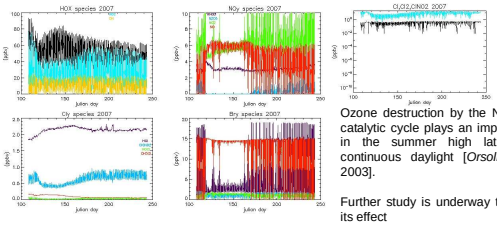


The time evolution of N_2O in the core of the FrIAC obtained by the CTM model is **quantitatively different** from the MLS measurements. However the **shape is similar** with a first step associated with constant high value of N_2O (typical of the tropics) during 40 days and then a decrease during 20 days to typical polar content.

The ozone mixing ratio rapidly decreases in the core of the FrIAC during the first 20 days. **Model results and MLS data are consistent regarding the ozone evolution**.

➢ Active chemistry in the core of the FrIAC : REPROBUS

The active chemistry from REPROBUS CTM model in the core of the FriAc is presented.

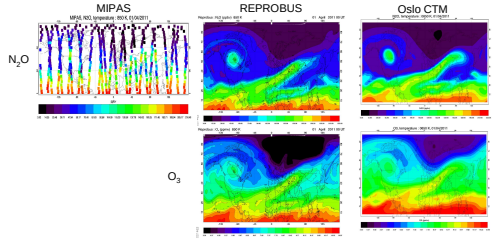


Ozone destruction by the NOx-driven catalytic cycle plays an important role in the summer high latitudes, in continuous daylight [*Orsolini et al.*, 2003].

Further study is underway to quantify its effect

The 2011 FrIAC Event : Comparison MIPAS/REPROBUS/Oslo CTM

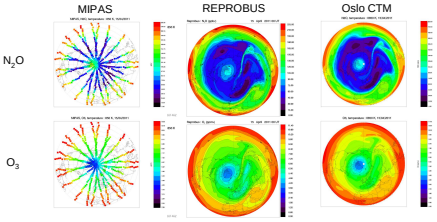
➢ On the 01 April 2011 : Intrusion



VMR (core FrIAC)	MIPAS	REPROBUS	CTM Oslo
N_2O ppbv	170-180	150-165	135-150
O_3 ppmv	9.5-9.8	8.7-9.1	8.4-8.7

During the first stage of the FrIAC (i.e. tropical intrusion) **both CTM models well represent** the location of the tropical intrusion. However the **maximum value of N_2O inside the tongue is underestimated** as for 2007 event.

➢ On the 15 April 2011



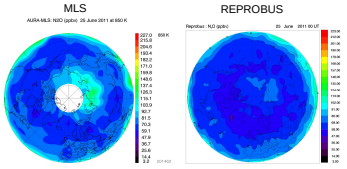
VMR (core FrIAC)	MIPAS	REPROBUS	CTM Oslo
N_2O ppbv	170	90-105	90-105
O_3 ppmv	3.5-4.5	3.6-4	3.6-4

Two weeks after the tropical intrusion stage, the FrIAC is well established in the summer polar circulation.

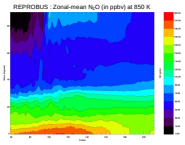
Both CTM models represent the dynamical signal in N_2O fields but **with lower value than the MIPAS measurements**.

Ozone fields are in good agreement and 15 days after the beginning of the FrIAC event, high O_3 tropical abundance has disappeared in the core of the FrIAC.

➢ On the 25 June 2011



VMR (core FrIAC)	MLS	REPROBUS
N_2O ppbv	>120	69-80
O_3 ppmv	3.5-4	3.0-3.5

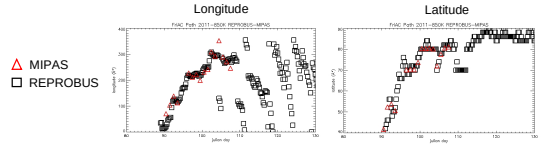


• The N_2O signal of the FrIAC has disappeared in the REPROBUS simulation on the 25 June, whereas this signal still exits in MLS data.

• The 2011 FrIAC event is centered on the North Pole ⇔ **difficulties to follow the evolution of this event with MLS data**.

• The zonal mean of N_2O fields shows that the FrIAC signal persists **50 days (more than 3 months)** in **REPROBUS (in MLS data)**.

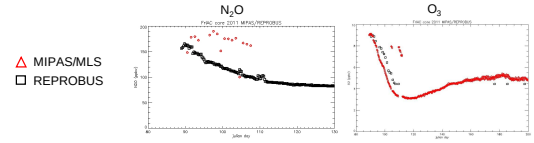
➢ Location of the core of the FrIAC : MIPAS/REPROBUS



The location of the core of the FrIAC on the 850K isentropic surface as a function of julian day, has been extracted from the MIPAS data and the results of REPROBUS using the criteria of the maximum value of N_2O mixing ratio at 850K.

The locations find using REPROBUS and MIPAS **are in agreement**.

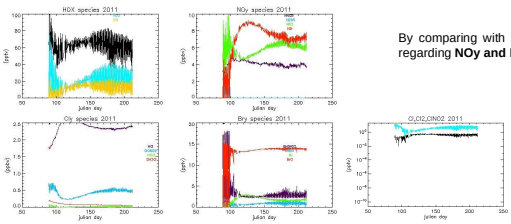
➢ N_2O and Ozone evolution in the core of the FrIAC : MIPAS & MLS/ REPROBUS



N_2O mixing ratio evolutions in the core of the FrIAC measured by MIPAS and simulated by REPROBUS are **different**. For the 2011 case, the model is **not able to conserve the N_2O signal** which starts to decrease from the beginning of the FrIAC.

O_3 evolution in the core of the FrIAC **is well represented** by the model.

➢ Active chemistry in the core of the FrIAC : REPROBUS



By comparing with the 2007 event, **strong discrepancies appear**; in particular regarding **NOy and HOx species.** This requires further investigations.

CONCLUSION :

The 2007 FrIAC event appears to be well represented by the REPROBUS CTM simulation. The N_2O signal is qualitatively in agreement with the shape of the N_2O evolution from MLS data, but the abundance of N_2O in the initial tropical intrusion is smaller in the model. O_3 mixing ratio evolution are very similar. In 15 days, a loss of ozone is observed in the core of the FrIAC. Such loss is being examined by investigating the chemical processes.

For the 2011 event, simulations have been made by two different CTM model, and in both cases, there are not able to represent the dynamical signature : N_2O high tropical values in the core of the FrIAC disappear too quickly (only 50 days).

O_3 evolution in the core of the 2011 FrIAC is, as for the 2007 event, in agreement with the measurements.

Additional work , has to be made, in particular with higher resolution simulations, to better understand why the CTMs are not able to represent the 2011 event. Allen et al. [2011] has encountered the same type of differences on the 2005 FriAC event.

Acknowledgments

This study has been conducted within the framework of the STRAPOLETE and ENRICHED project supported by the "Agence Nationale de la Recherche ANR (STRAPOLETE project ANR 08 BLAN 0300), the "Institut Polaire Paul Emile Victor" (IPEV) and the "Centre National d'Etudes Spatiales (CNES)". We thanks ETHER CNES/INSU data base. For their support. the EOS-MLS instrument science team, and MIPAS-IMK science team for the satellite data and the European Centre for Medium-Range Weather Forecasts for providing the ERA-Interim data.

References

R. Thiéblemont, N. Huret, Y.J. Orsolini, A. Hauchecorne and M.-A. Drouin (2011), *JGR*, 116, D20110, doi:10.1029/2011JD016042.
Manney et al. (2006), *GRL*, 33, L06810, doi:10.1029/2005GL025418.
Orsolini Y.J. et al. (2003), *QJRMS*, 129, 595, 3265-3275, doi:10.1256/qj.02.211.
Lefèvre et al. (1994), JGR, 99, 8183-8195, doi:10.1029/93JD03476.
Allen et al. (2011), *ACP*, 11, 4557-4576, doi:10.5194/acp-11-4557-2011.
W. Lahoz, A.J. Geer and Y.J. Orsolini (2007), *QJRMS*, 133, 197-211.
Søvde et al. (2011), *QJRMS*, 137, 654, 118-128.